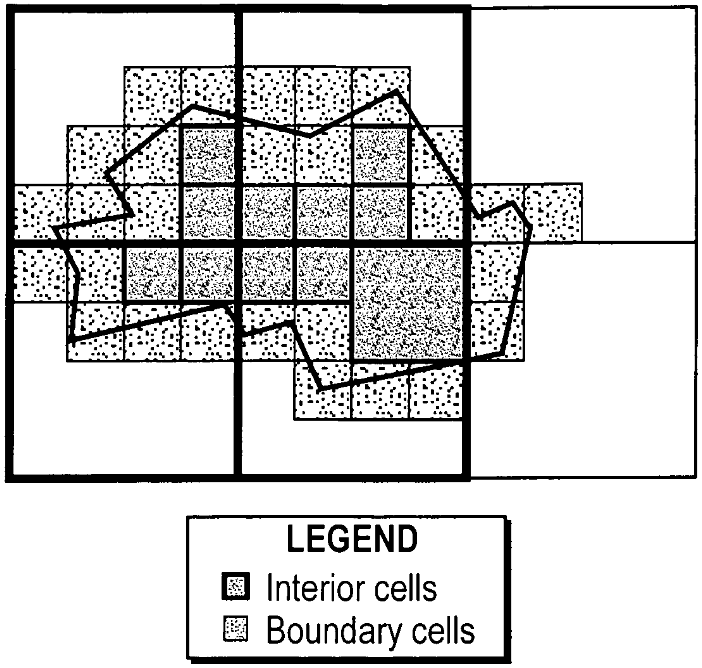


FIG. 1
(PRIOR ART)

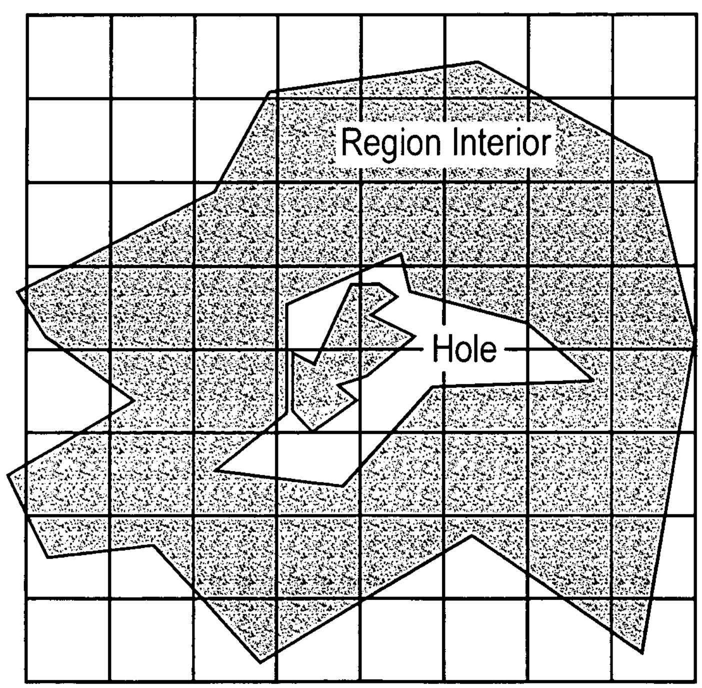


FIG. 2
(PRIOR ART)

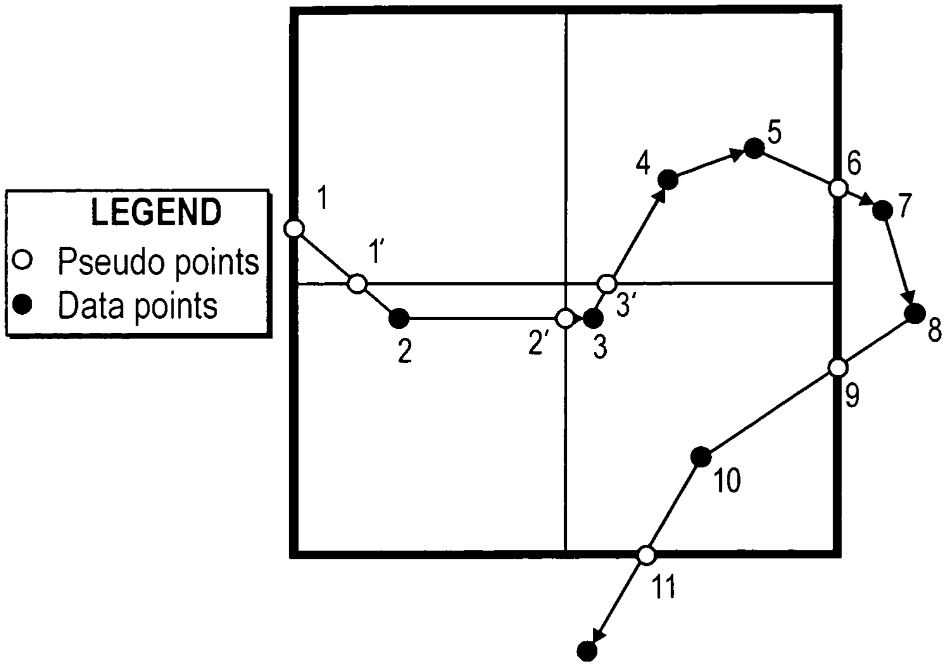


FIG. 3

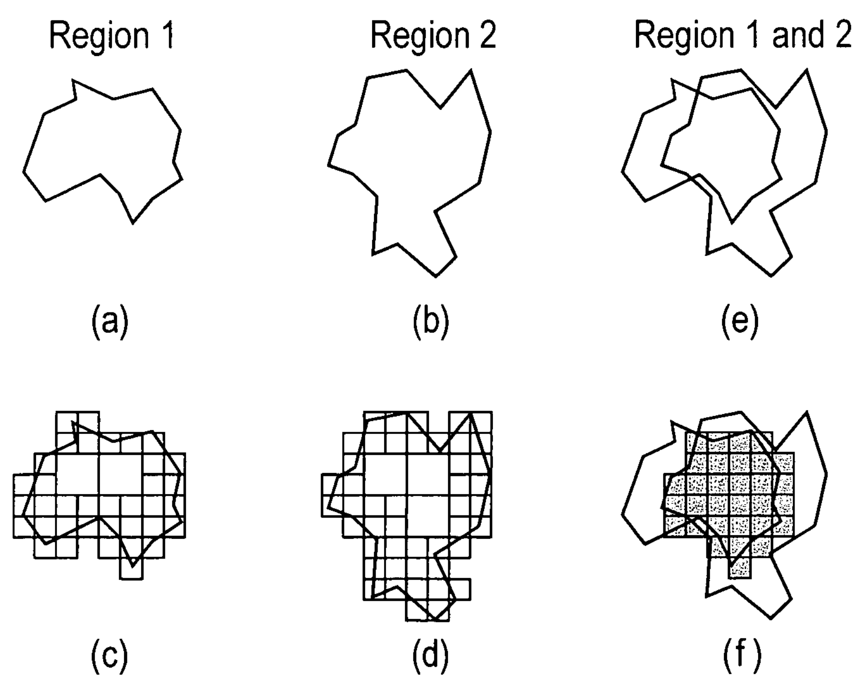


FIG. 4
(PRIOR ART)

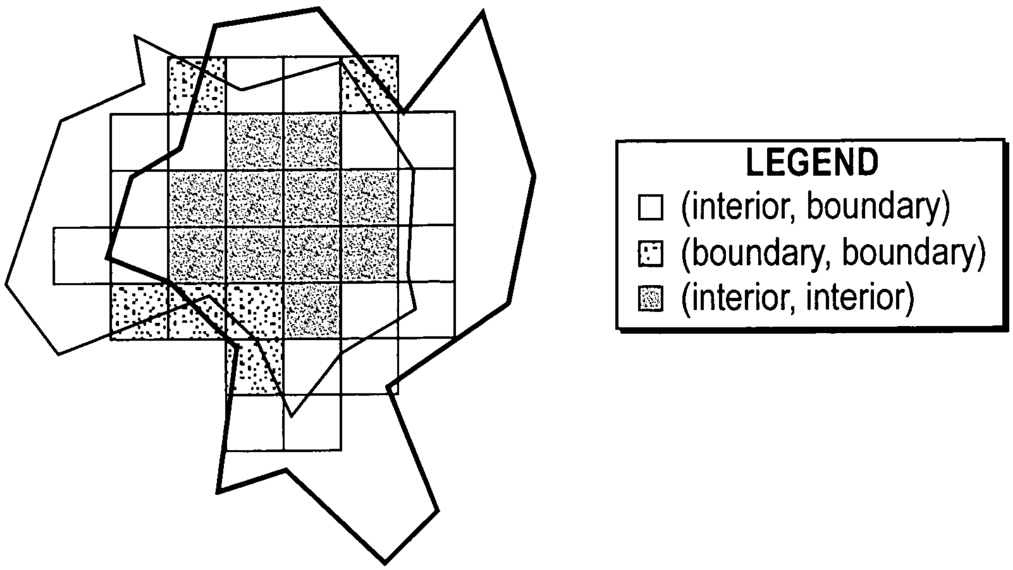


FIG. 5
(PRIOR ART)

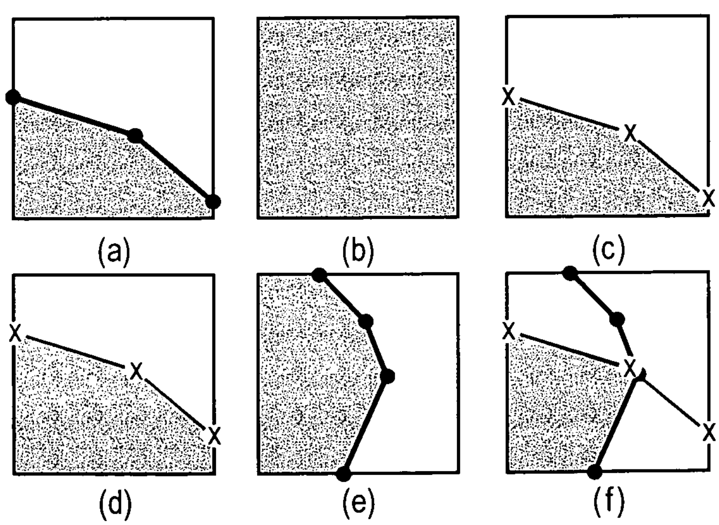


FIG. 7
(PRIOR ART)

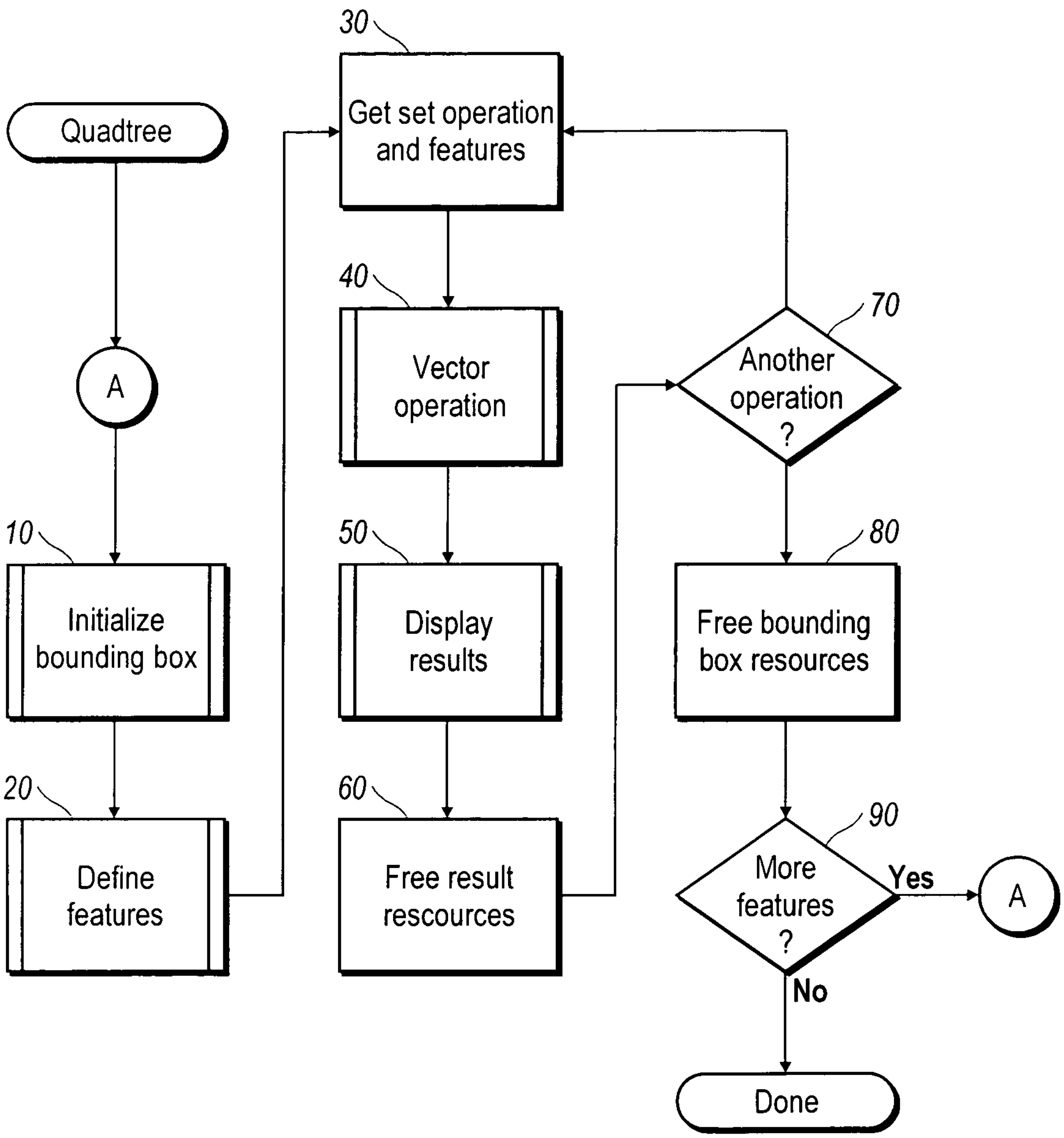
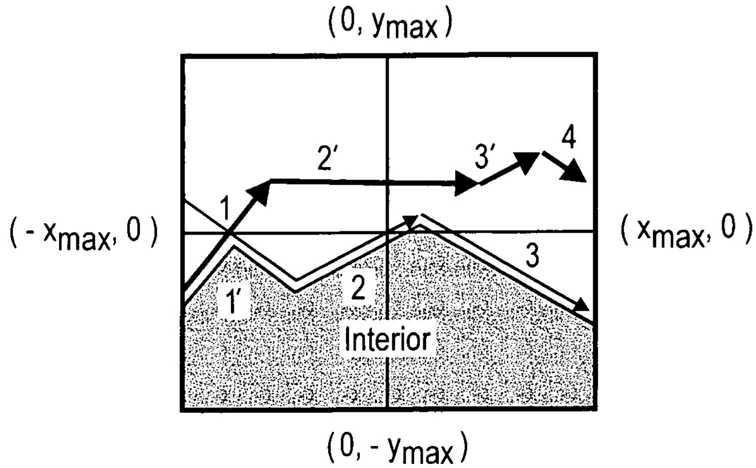
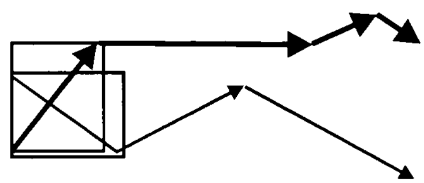

Quadtree
A
10
Initialize bounding box
20
Define features
30
Get set operation and features
40
Vector operation
50
Display results
60
Free result rescources
70
Another operation ?
80
Free bounding box resources
90
More features ?
Yes
A
No
Done

FIG. 6



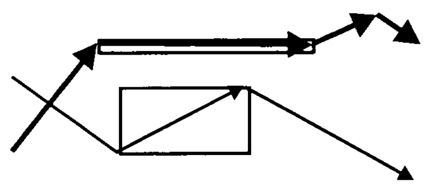
Line segment intersection cases

The two bounding boxes associated with the first two tuple-pairs from both features intersects as shown to the right



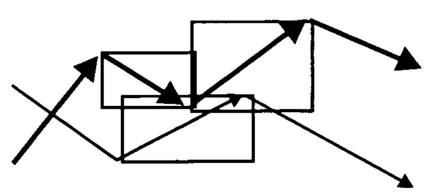
Case 1

The bounding boxes associated with the second set of tuple-pairs do not intersect



Case 2

In the case to the right, two black line segments must be elevated for intersection with a single red line segment



Case 3

FIG. 8

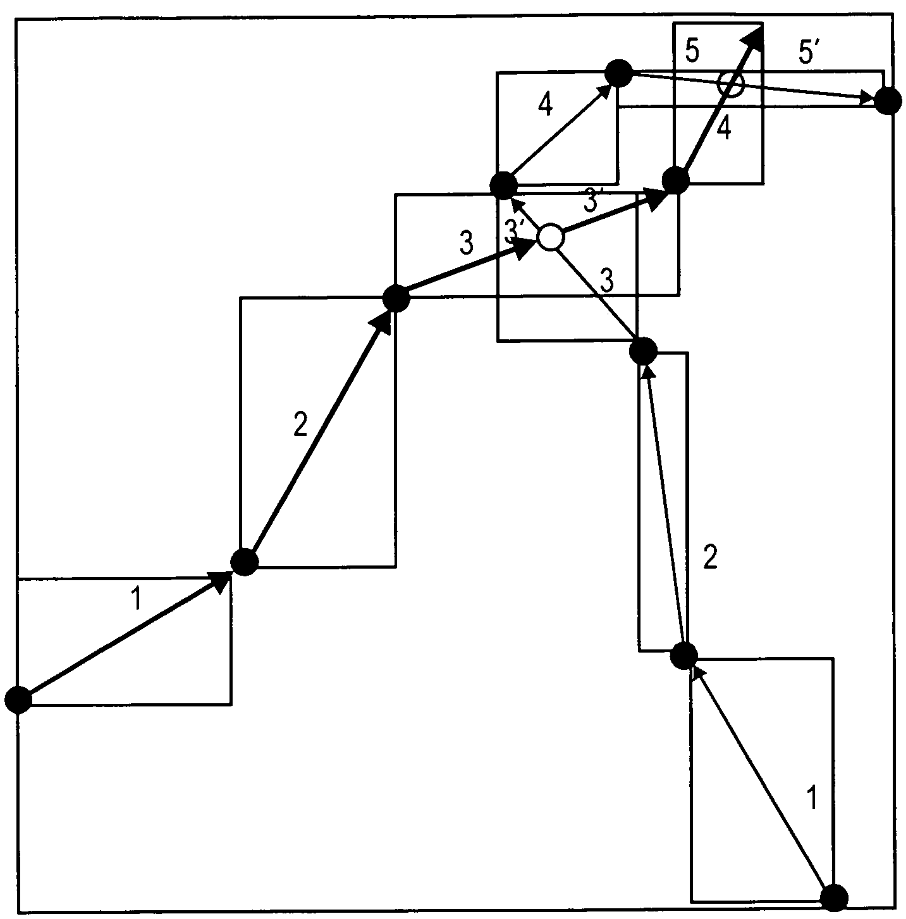


FIG. 9

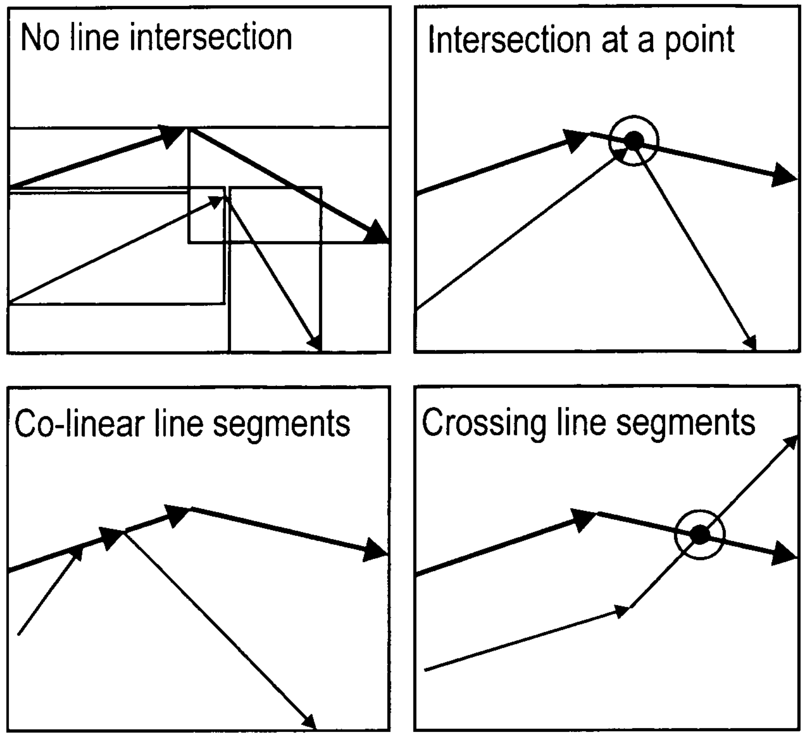

No line intersection
Intersection at a point
Co-linear line segments
Crossing line segments

FIG. 10

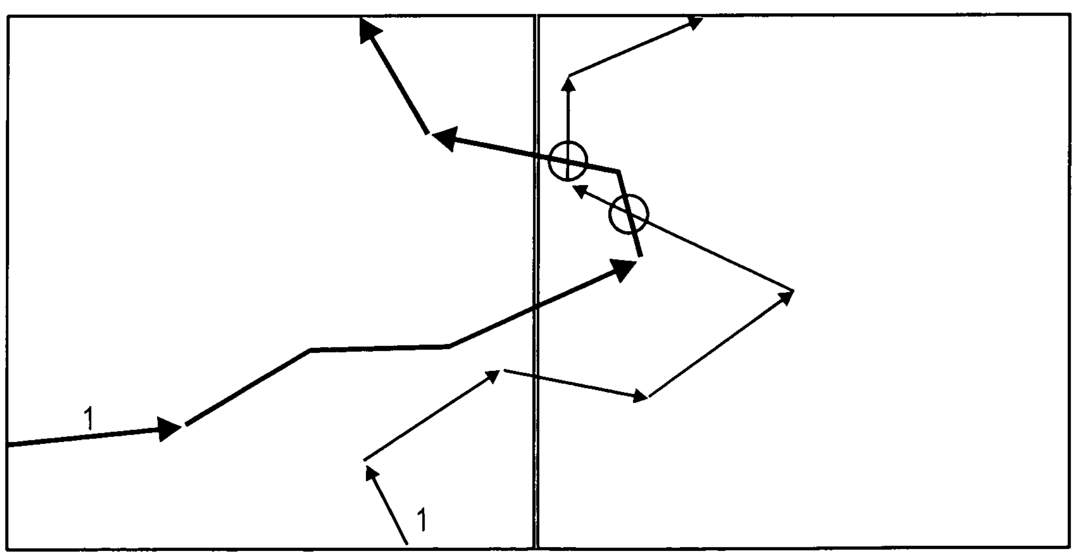

1
1

FIG. 11

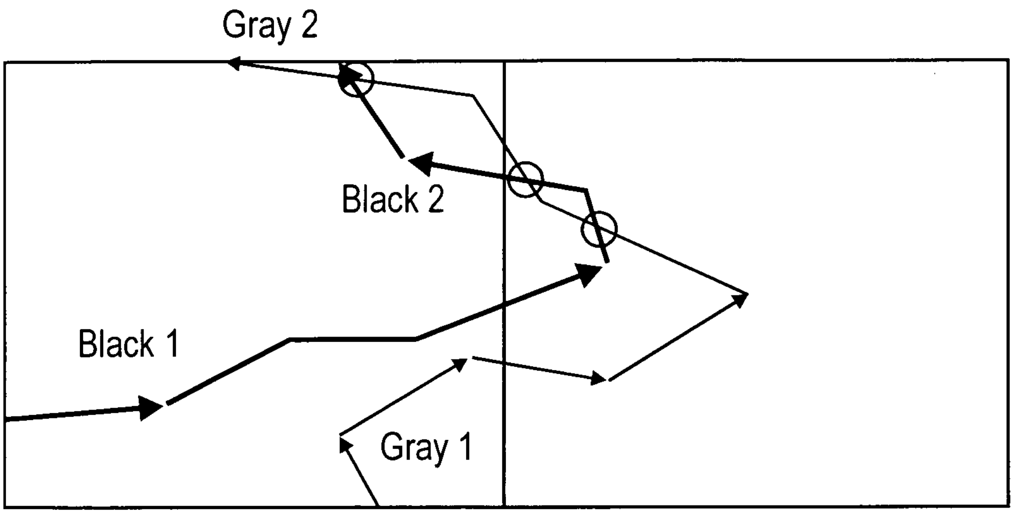


FIG. 12

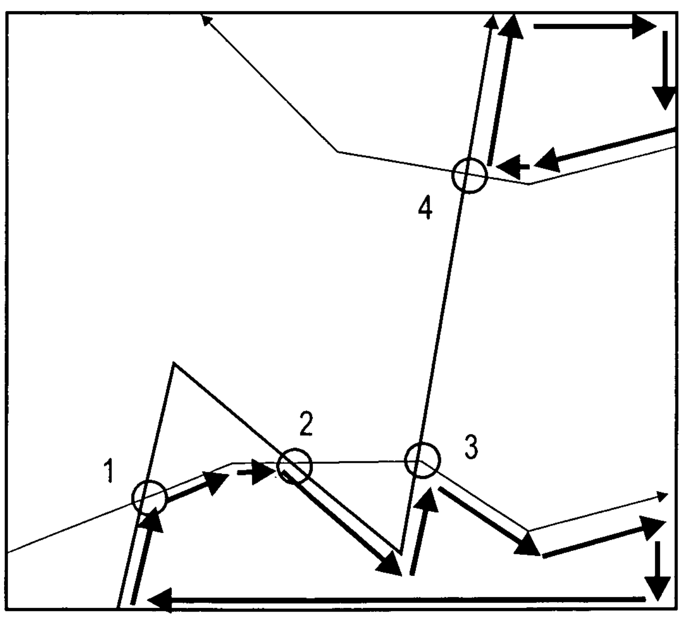


FIG. 13

Possible cell entrance/exit point combinations

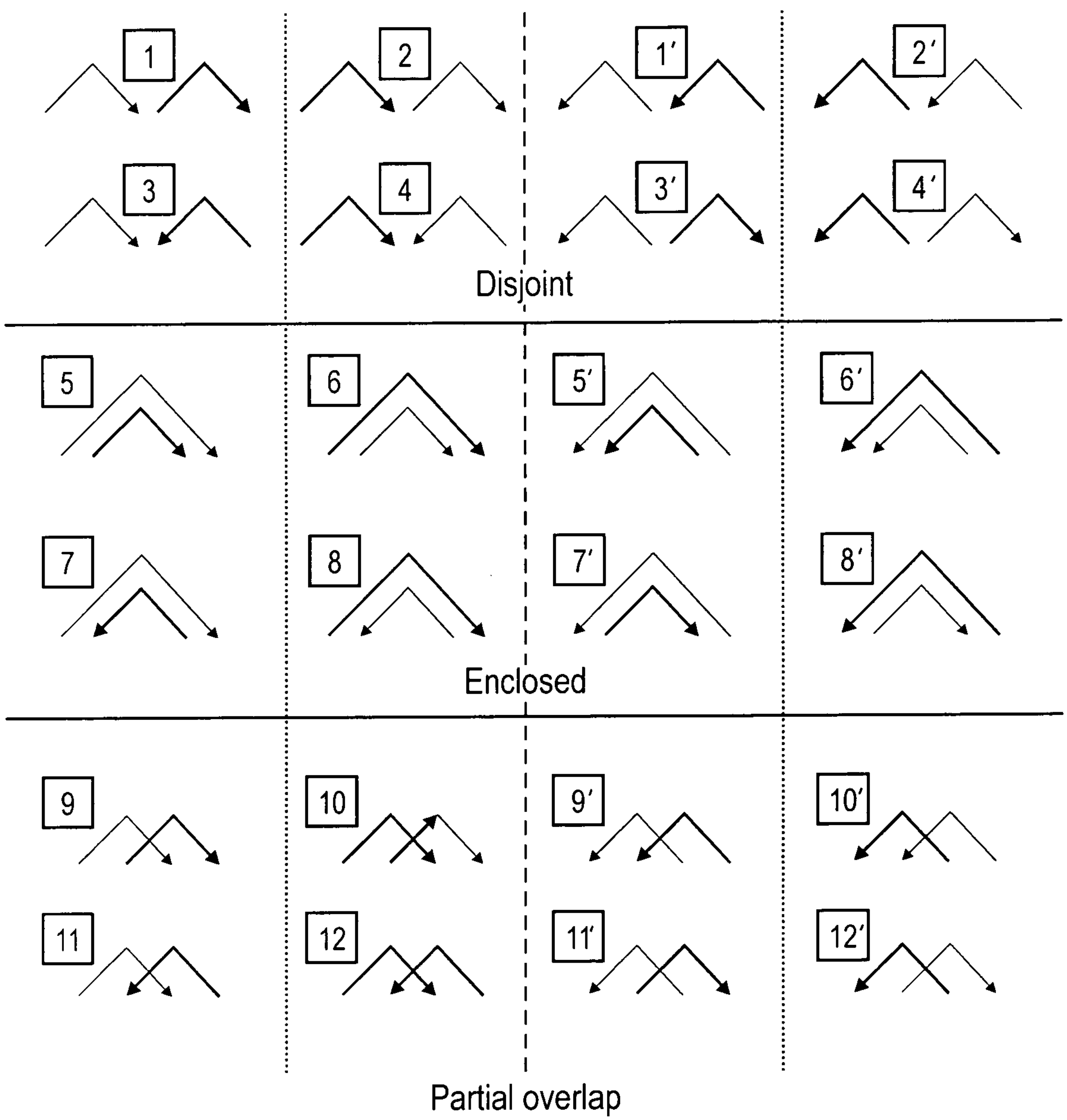


FIG. 14

Entry/Exit Relationship	Class	Begin point for first cycle (inside is " to the right ") **Intersection**	Begin point for first cycle (inside is " to the right ") **Union**	Begin point for first cycle (inside is " to the left ") **Intersection**	Begin point for first cycle (inside is " to the left ") **Union**
$G_E G_X B_E B_X$	I	First intersection point of black or gray feature (Null if no intersect points)	Pseudo points (B_E and G_E)	Pseudo points (B_E and G_E)	First intersection point of black or gray feature (Full cell if no intersect points)
$G_E B_X B_E G_X$	II	Pseudo points (B_E and G_E)	First intersection point of black or gray feature (Full cell if no intersect points)	First intersection point of black or gray feature (Null if no intersect points)	Pseudo points (B_E and G_E)
$G_E B_E B_X G_X$	III	Pseudo point B_E	Pseudo point G_E	Pseudo point G_E	Pseudo point B_E
$G_E B_E G_X B_X$	VI	Pseudo point B_E	Pseudo point G_E	Pseudo point G_E	Pseudo point B_E
$G_E G_X B_X B_E$	IV	Pseudo point G_E	Pseudo point B_E	Pseudo point B_E	Pseudo point G_E
$G_E B_X G_X B_E$	V	Pseudo point G_E	Pseudo point B_E	Pseudo point B_E	Pseudo point G_E

Application of table:

Follow specified boundary entrance feature, accumulating intersection and/or union cycles until all polyline intersection point tuples in the cell have been exhausted.

Cycles alternate systematically along the specified entrance feature between contributions to intersection and union.

Cycles are completed when they close on themselves. The implicit boundary-closing segments of a boundary-closing cycle are not actually represented in the general product.

Comments:

As is apparent from the above formulation, intersection and union are effectively dual operations. The set operation generation procedure is similar regardless of the ordering convention of the polygon tuples (clockwise or counter-clockwise oriented), reflected in the symmetry observed within the above table.

Note that the classes are grouped into pairs. Classes I and II involve inverse operations;

Classes III and VI employ identical generation operations, as do Classes IV and V .

FIG. 15

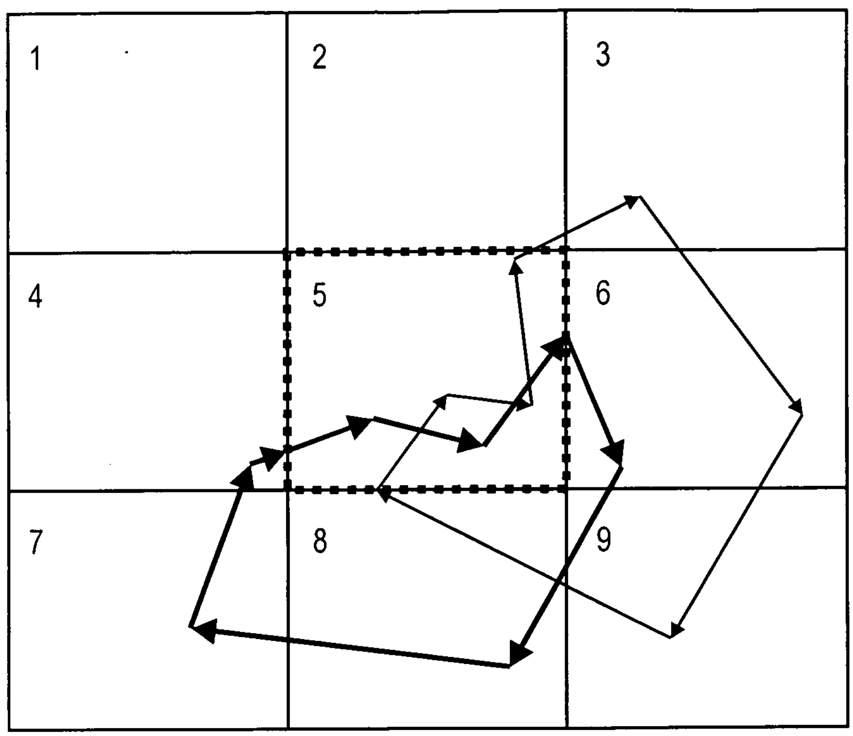


FIG. 16

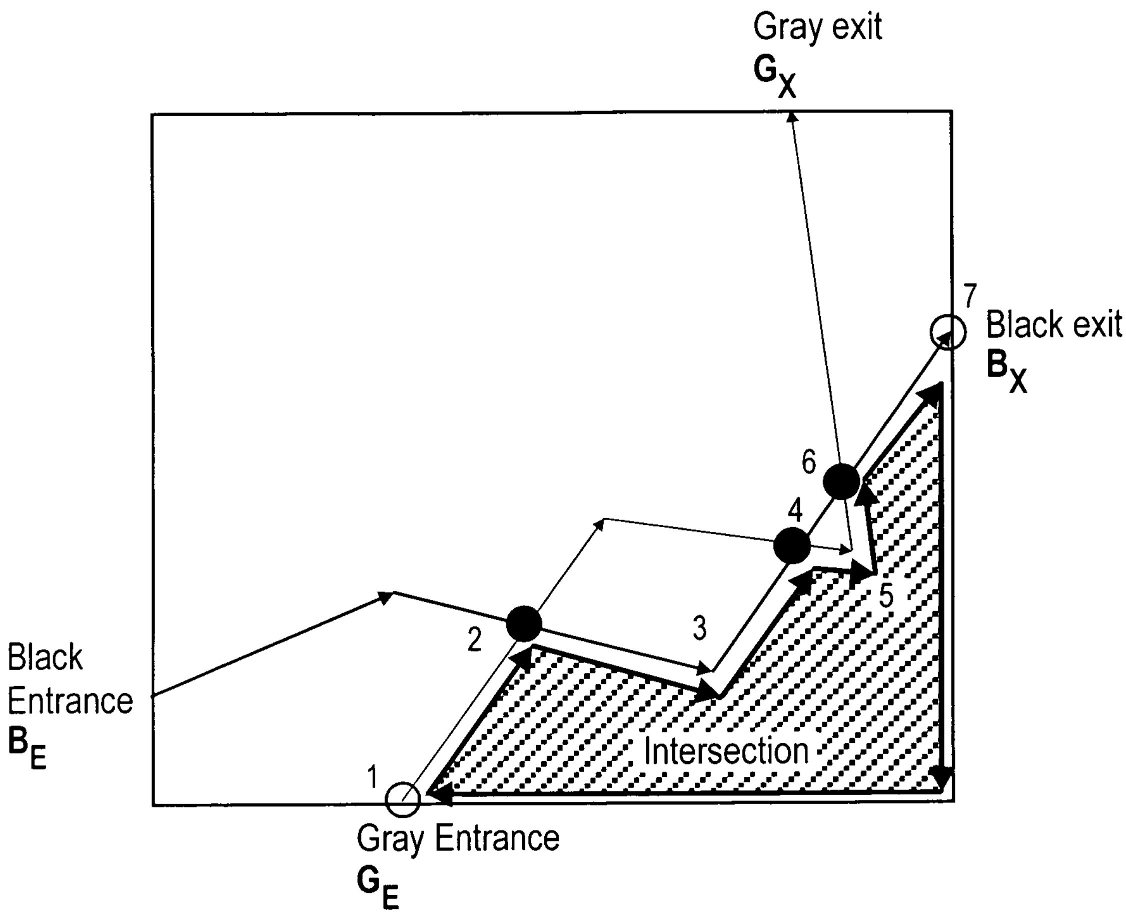

Gray exit
G_X
7
Black exit
B_X
6
4
2
3
5
Black
Entrance
B_E
Intersection
1
Gray Entrance
G_E

FIG. 17

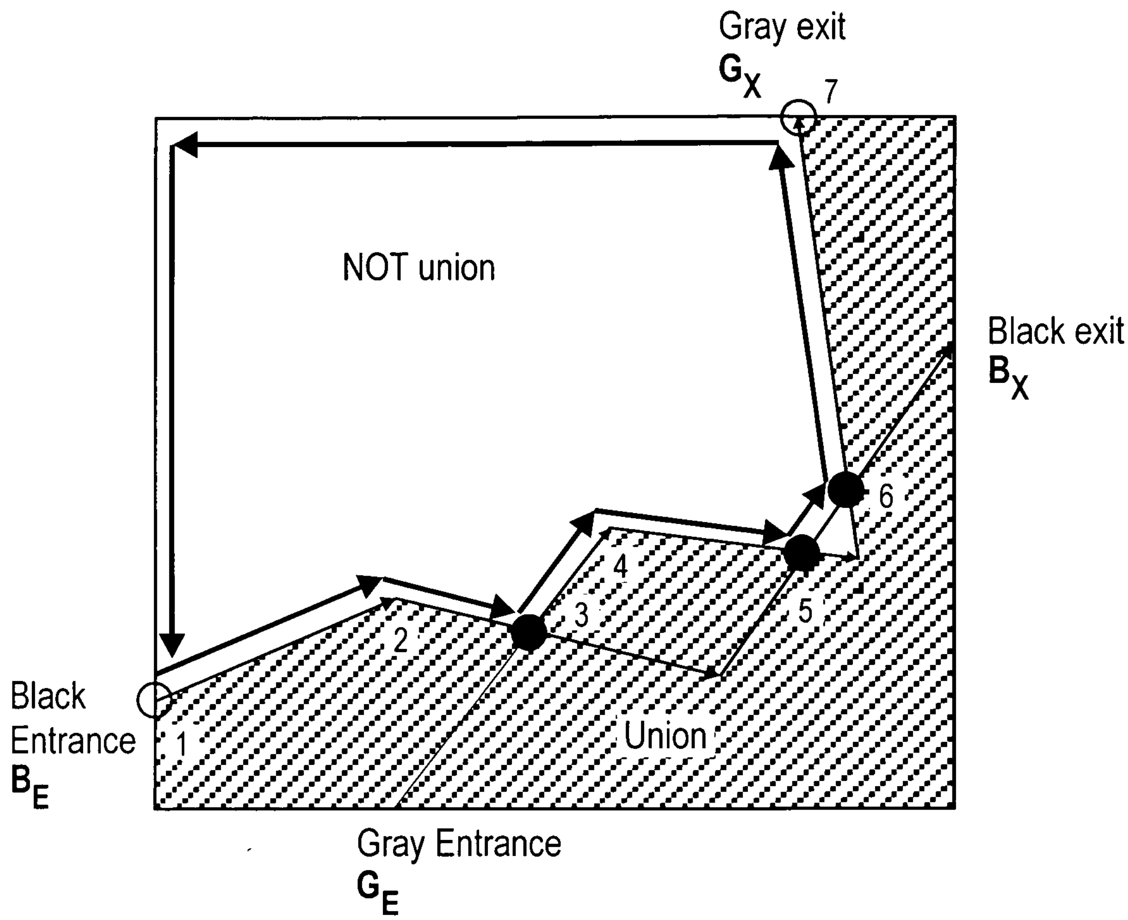

Gray exit
G_X
7
NOT union
Black exit
B_X
6
4
5
3
2
Black
Entrance
B_E
1
Union
Gray Entrance
G_E

FIG. 18

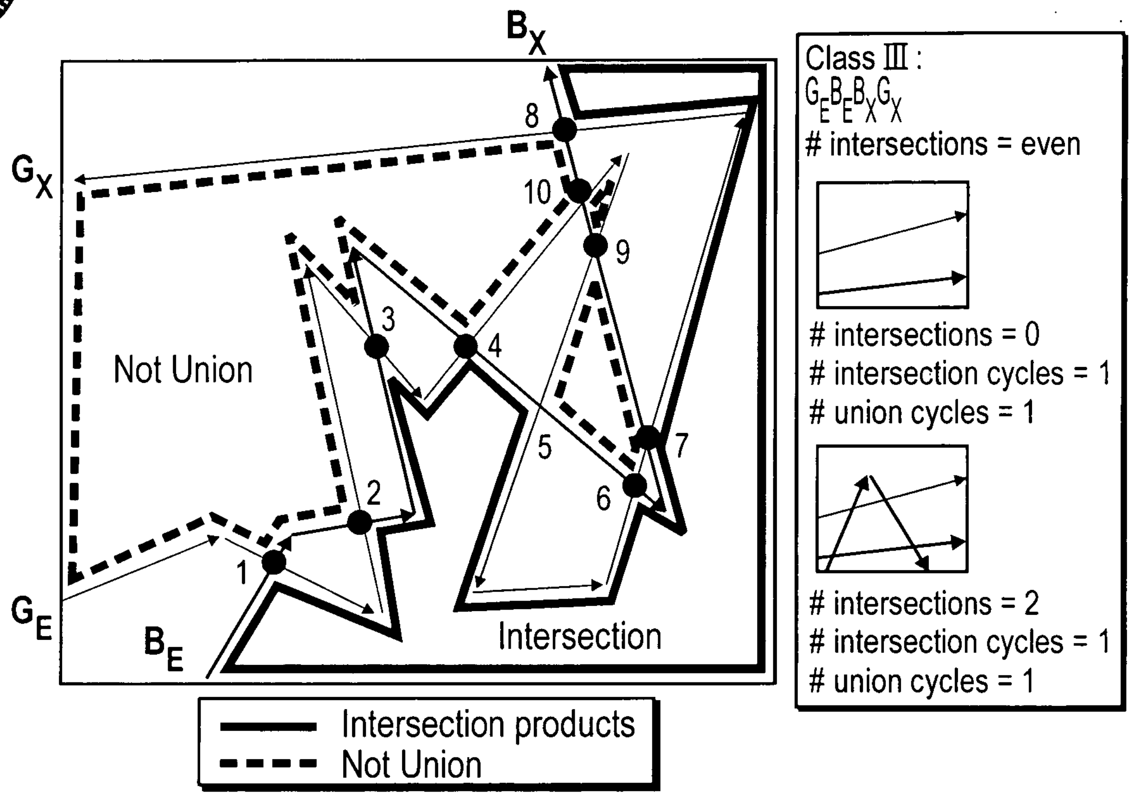

B_X
G_X
G_E
B_E
Not Union
Intersection
1
2
3
4
5
6
7
8
9
10
Class III :
$G_EB_EB_XG_X$
intersections = even
intersections = 0
intersection cycles = 1
union cycles = 1
intersections = 2
intersection cycles = 1
union cycles = 1
Intersection products
Not Union

FIG. 19

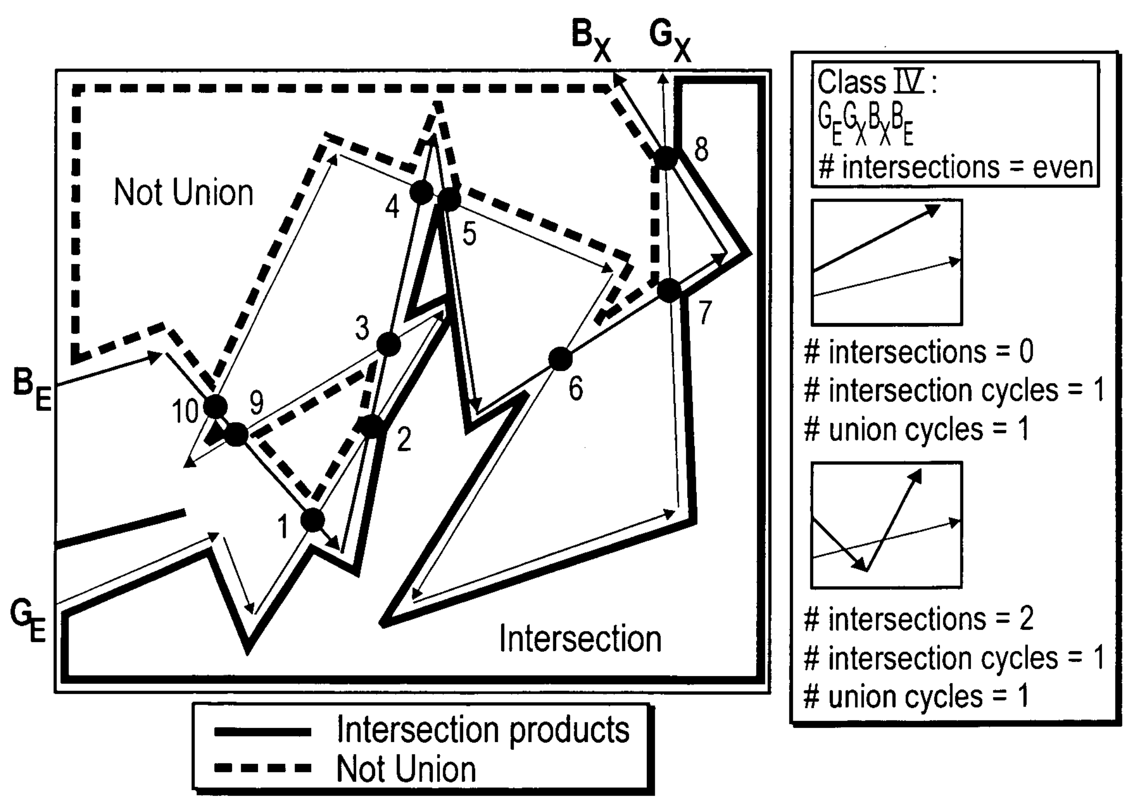

B_X
G_X
B_E
G_E
Not Union
Intersection
1
2
3
4
5
6
7
8
9
10
Class IV :
$G_EG_XB_XB_E$
intersections = even
intersections = 0
intersection cycles = 1
union cycles = 1
intersections = 2
intersection cycles = 1
union cycles = 1
Intersection products
Not Union

FIG. 20

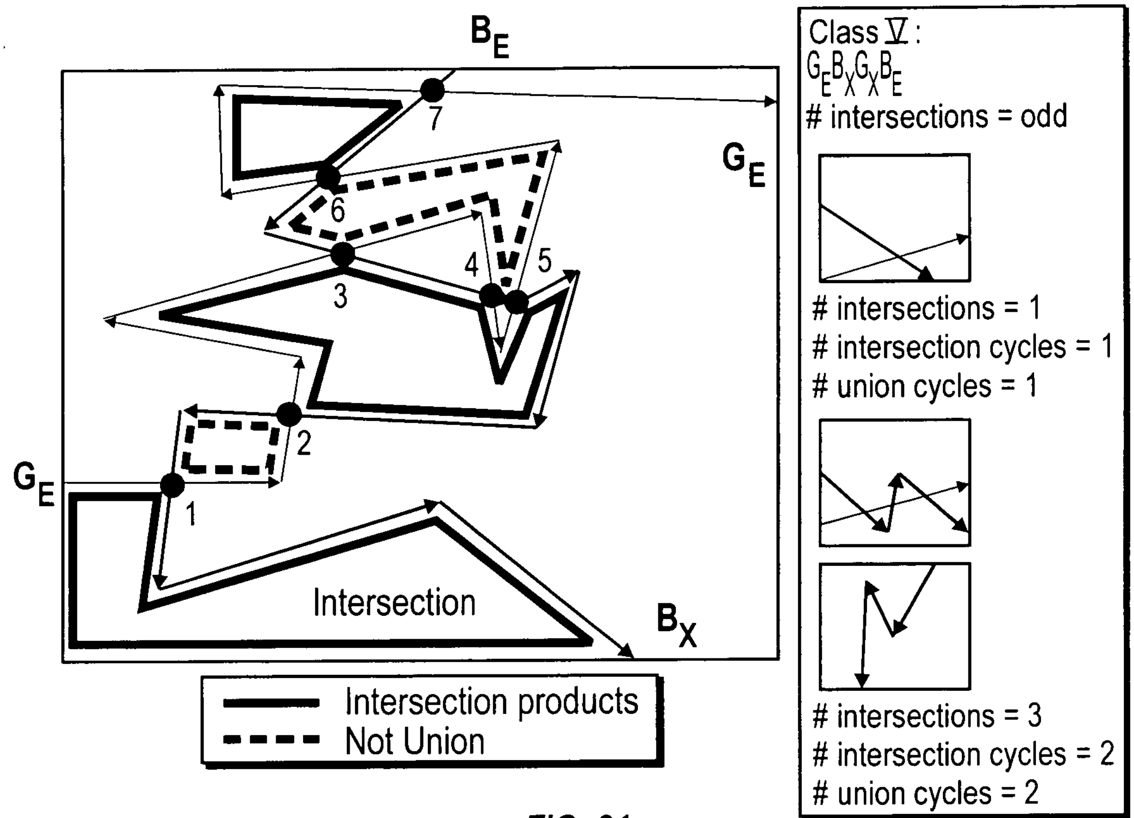

B_E
G_E
G_E
B_X
1
2
3
4
5
6
7
Intersection
Intersection products
Not Union
Class V :
$G_EB_XG_XB_E$
intersections = odd
intersections = 1
intersection cycles = 1
union cycles = 1
intersections = 3
intersection cycles = 2
union cycles = 2

FIG. 21

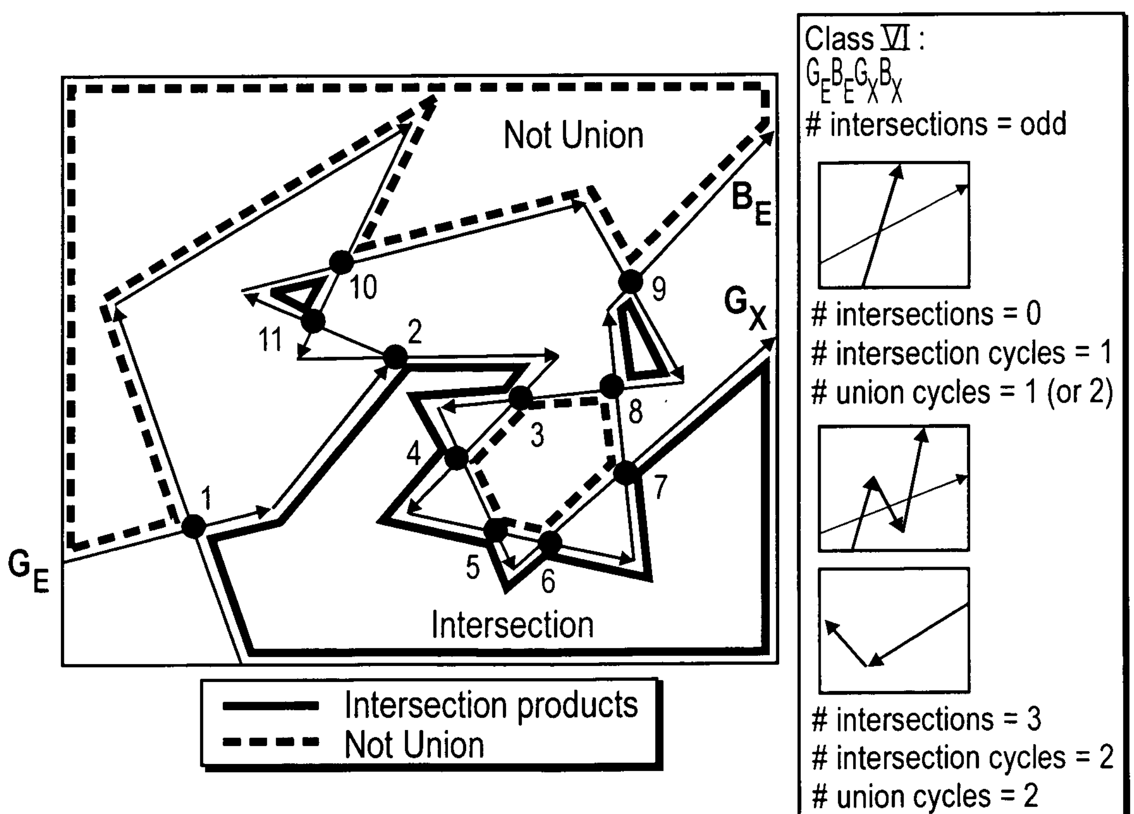

Not Union
B_E
G_X
G_E
1
2
3
4
5
6
7
8
9
10
11
Intersection
Intersection products
Not Union
Class VI :
$G_EB_EG_XB_X$
intersections = odd
intersections = 0
intersection cycles = 1
union cycles = 1 (or 2)
intersections = 3
intersection cycles = 2
union cycles = 2

FIG. 22

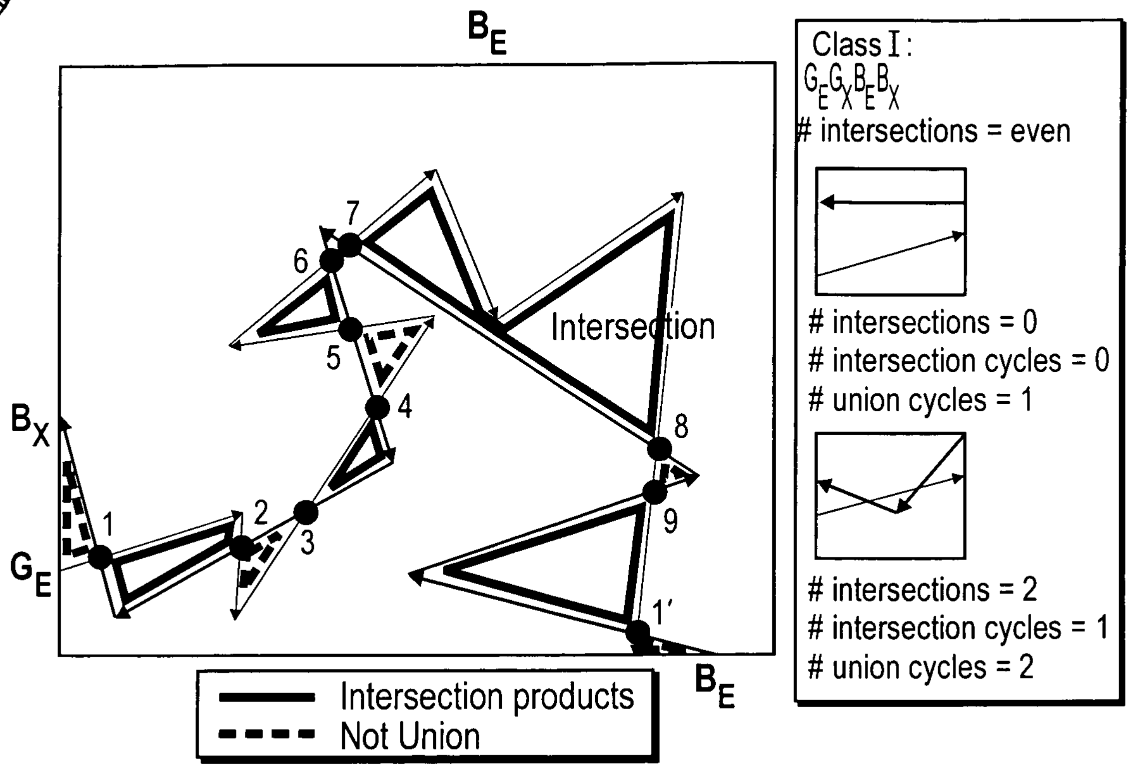

B_E
B_X
G_E
B_E
1
2
3
4
5
6
7
8
9
1′
Intersection
Intersection products
Not Union
Class I:
G_E G_X B_E B_X
intersections = even
intersections = 0
intersection cycles = 0
union cycles = 1
intersections = 2
intersection cycles = 1
union cycles = 2

FIG. 23

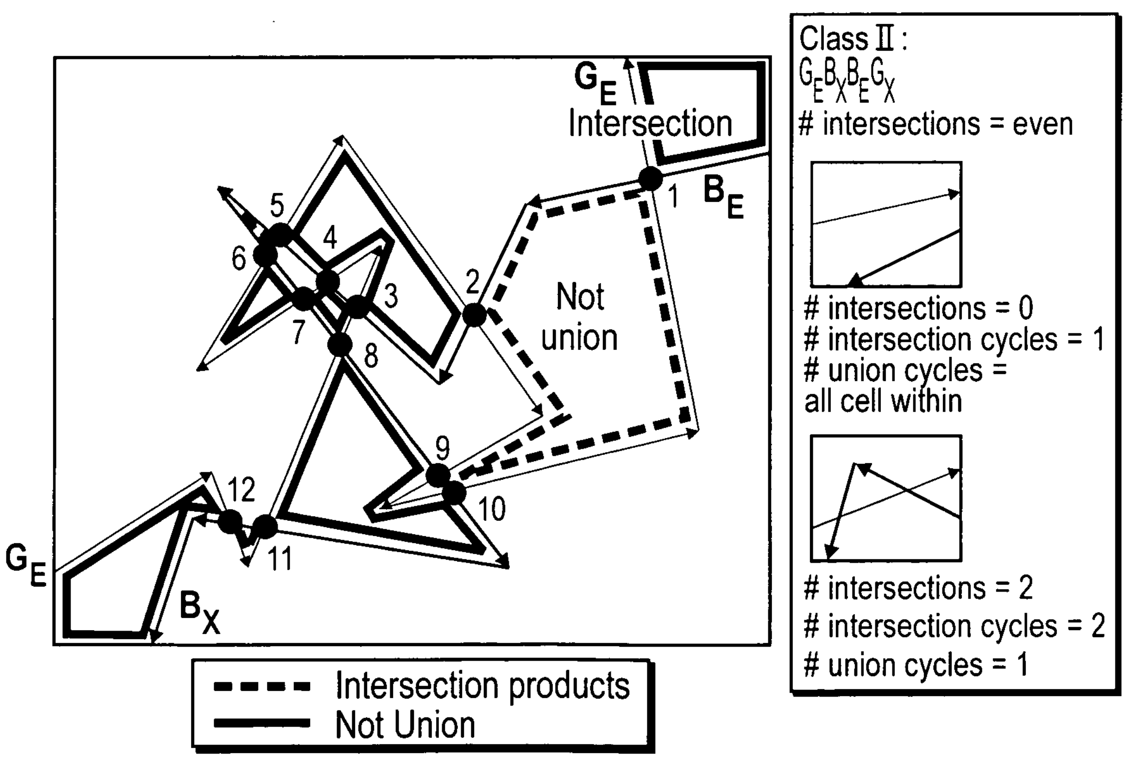

G_E
Intersection
B_E
1
2
3
4
5
6
7
8
9
10
11
12
Not union
G_E
B_X
Intersection products
Not Union
Class II:
G_E B_X B_E G_X
intersections = even
intersections = 0
intersection cycles = 1
union cycles =
all cell within
intersections = 2
intersection cycles = 2
union cycles = 1

FIG. 24

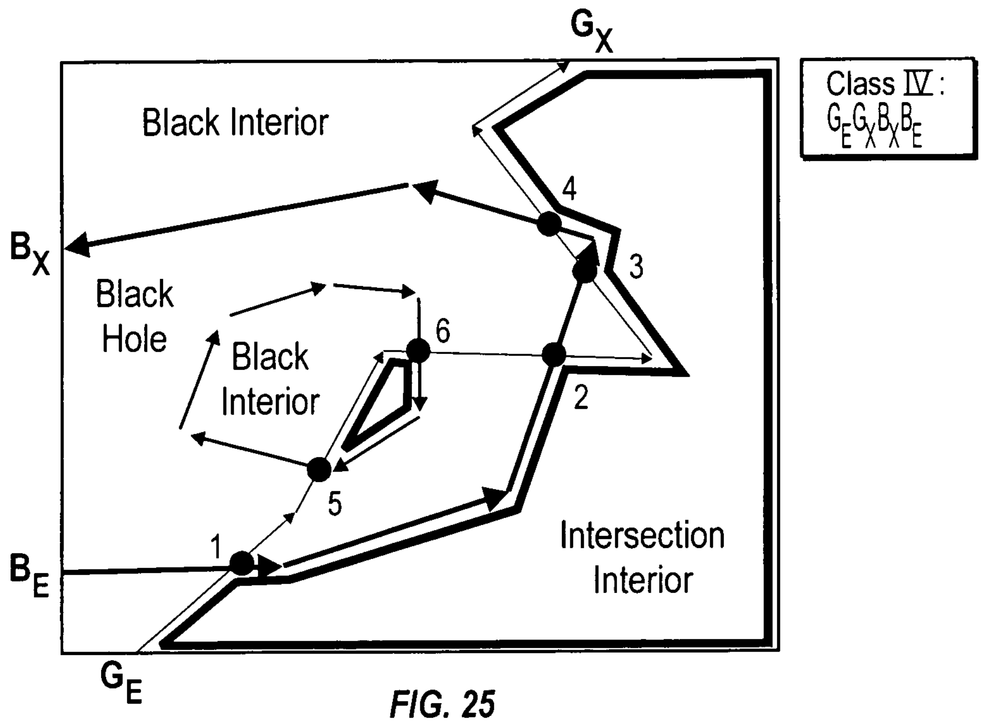

G_X
Class IV :
$G_E G_X B_X B_E$
Black Interior
B_X
Black Hole
Black Interior
4
3
6
2
5
1
B_E
Intersection Interior
G_E

FIG. 25

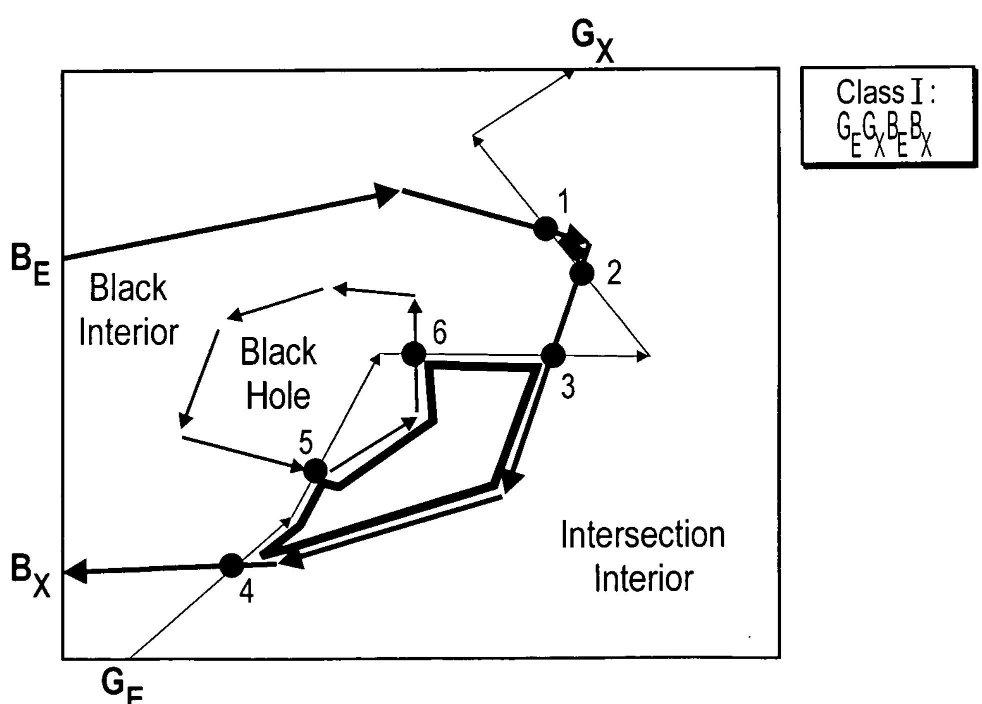

G_X
Class I :
$G_E G_X B_E B_X$
B_E
1
2
Black Interior
Black Hole
6
3
5
B_X
4
Intersection Interior
G_E

FIG. 26

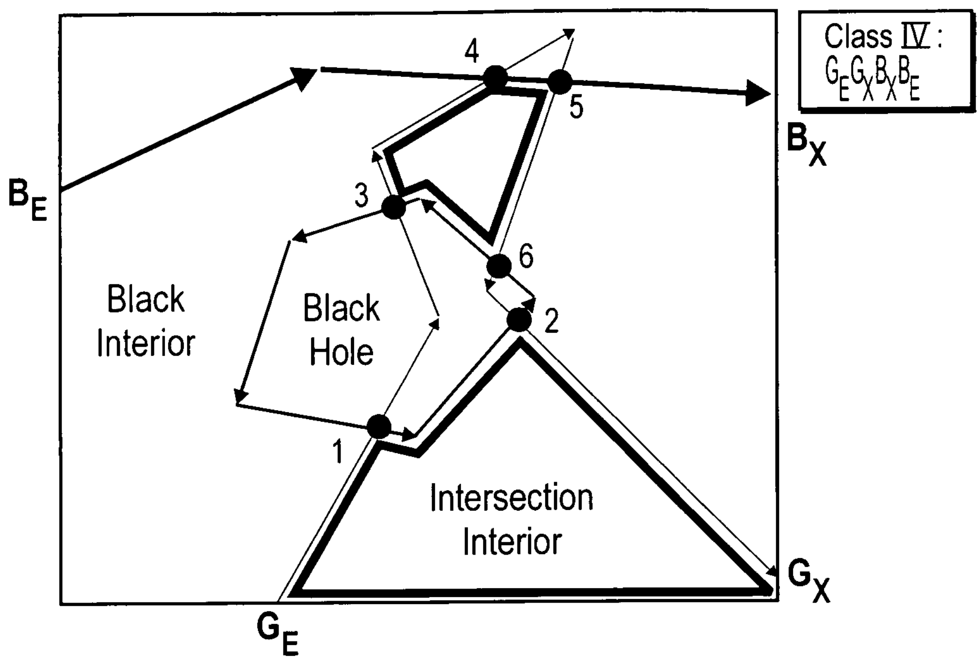

Class IV:
$G_E G_X B_X B_E$
4
5
B_X
B_E
3
6
2
1
Black Interior
Black Hole
Intersection Interior
G_X
G_E

FIG. 27

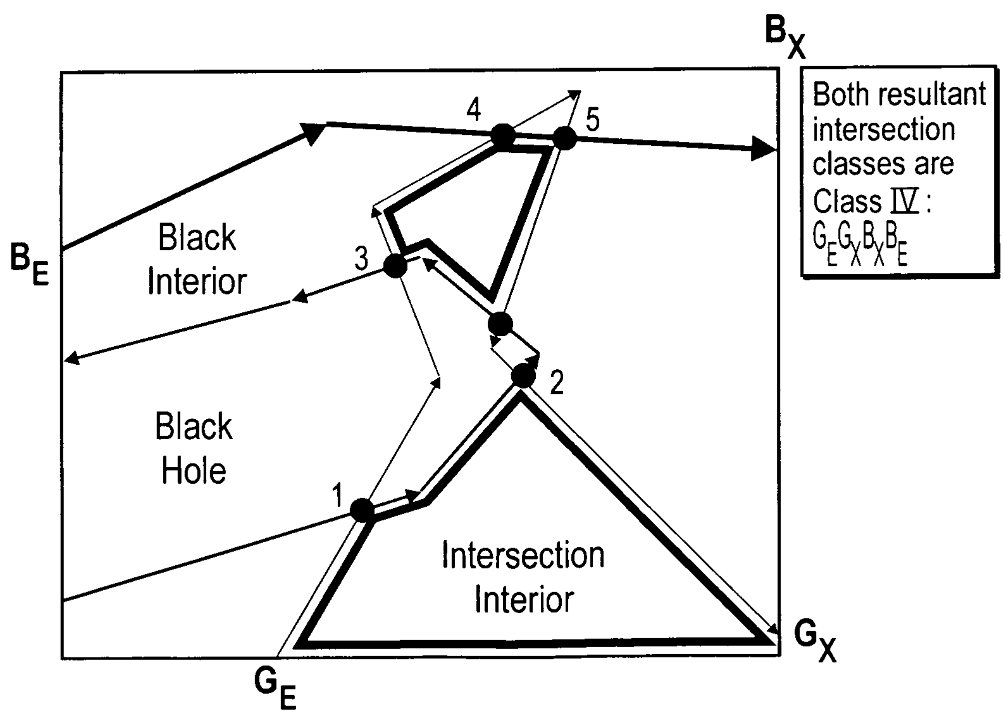

B_X
Both resultant intersection classes are Class IV:
$G_E G_X B_X B_E$
4
5
B_E
Black Interior
3
2
Black Hole
1
Intersection Interior
G_X
G_E

FIG. 28

Entry/Exit Relationship	Class	Total # of Intersection tuples within cells	Entry/exit relationship adjacent/ alternating	Special cases # Intersect points	Total Intersect Cycles (to the right)	Total # of NOT union cycles (to the right)	Total Intersect Cycles (to the left)	Total # of NOT union cycles (to the left)
$G_E G_X B_E B_X$	I	even	Adjacent	0 2	0 1	2 2	1 1	Full cell 2
$G_E B_X B_E G_X$	II	even	Adjacent	0 2	1 2	Full cell 1	0 2	2 1
$G_E B_E B_X G_X$	III	even	Adjacent	0 2	1 1	1 1	1 1	1 1
$G_E B_E G_X B_X$	VI	odd	Alternating	1	1	1	1	1
$G_E G_X B_X B_E$	IV	even	Adjacent	0 2	1 1	1 1	1 1	1 1
$G_E B_X G_X B_E$	V	odd	Alternating	1	1	1	1	1

FIG. 29

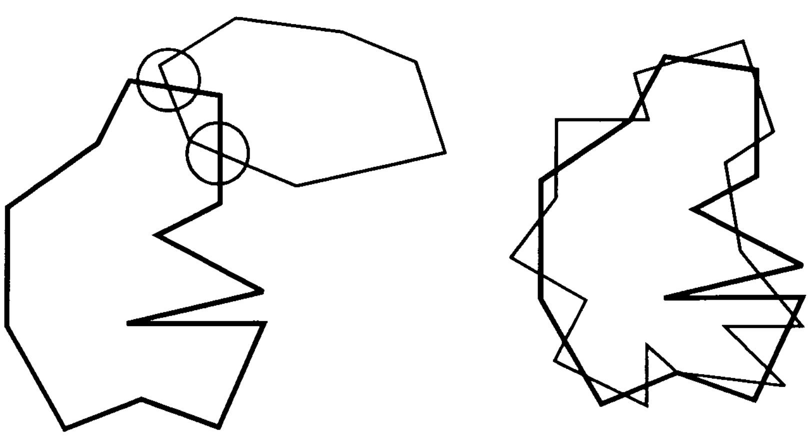


FIG. 30